Comprehensive Numerical Modeling of the Adriatic Sea

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LONG-TERM GOALS

A better understanding of oceanic variability via modeling studies of circulation, entrainment, mixing and convection in the coastal ocean. Development and use of models for the study of generic processes and for the investigation of specific oceanic regions. Transition of these models to the US Navy.

OBJECTIVES

Development of a comprehensive, finite-element model of the Adriatic Sea, with initial focus on the seasonal circulations and later applications to mesoscale variability. Comparison of model results with those of other regional modeling efforts.

APPROACH

A high-resolution finite-element grid was constructed for the entire Adriatic Sea using the finest available topography and coastline data sets. The 3D finite-element model developed at Dartmouth (Lynch et al., 1996) is being progressively developed and applied to simulate the following dynamics: (1) Precise tidal simulations to test the model's resolution in the barotropic mode and to obtain tidal currents, (2) simulation of the circulation on seasonal time scales to test the model's performance in the baroclinic mode and to understand the baseline circulation, (3) study of events (wind storms, anomalous river discharges, mesoscale instabilities) on scales of days and weeks, (4) performance comparison against observations and with other models, and (5) focus on particular regions.

WORK COMPLETED

Our tidal calculations have been completed, and this part of the work is now in the publication stage. A paper presenting the model and barotropic tidal simulations has been submitted for publication (Cushman-Roisin and Naimie, 1999). Alongside, tidal calculations were performed with another model (two-dimensional but with higher horizontal resolution) for the northern basin of the Adriatic (Malacic, Viezzoli and Cushman-Roisin, 1999).

To prepare the model for baroclinic simulations, we collected several temperature and salinity data sets of the Adriatic Sea, reviewing their contents and assessing their suitability to our model objectives. These data sets are the Mediterranean Ocean Data Base (MODB, which contains the MED2 and MED5 datasets) and the Adriatic Temperature, Oxygen and Salinity (ATOS). After due consideration, we realized that a more comprehensive dataset could be formed by assembling the available ungridded data. While this approach provided much needed additional coverage, the density of data in the Adriatic at some particular times of the year remained low. The results of statistical analysis suggested pooling the data into the following climatological seasons: winter (January-March), spring (April-June), summer (July-September) and fall (October-December). The new dataset was then objectively interpolated to our finite-element grid and dynamically adjusted to remove vertical density inversions.

In the next phase, the model was used to calculate the baroclinic circulation for each of the four seasons (Figure 1.). We are currently comparing the model outputs with recent geostrophic calculations (Buljan and Zore-Armanda, 1976; Artegiani et al., 1997) and with the Eulerian circulation derived from drifter data (Poulain, 1999b).

Alongside, we have been compiling information and writing chapters in preparation of the ONR-supported book "Oceanography of the Adriatic Sea: Past, Present and Future" (under contract with Kluwer Academic Publishers). While this book emerges from the recent International Workshop on the Oceanography of the Adriatic Sea (Trieste, September 1998), it is meant to be far more comprehensive than mere conference proceedings, being intended to provide an up-to-date review of the physical oceanography of the Adriatic Sea and to serve as a reference monograph for Adriatic and Mediterranean researchers in the next decade. Publication is scheduled for the latter part of 2000.

Lastly, Drs. Pierre-Marie Poulain (Naval Postgraduate School) and M. Tamay Ozgokmen (University of Miami) came to Dartmouth in September 1999 to begin the comparison between observed surface drifter tracks and numerically simulated trajectories. Because of the unusually good grouping of drifters along the eastern coast (Albania, Yugoslavia and Croatia) during the summer of 1995, this region at that period was selected for a preliminary comparison. Also, to add realism to the simulations, NORAPS winds (Horton et al., 1997) were included.

RESULTS

At this junction, our results consist in (1) a new temperature and salinity data base, called the Dartmouth Adriatic Data Base (DADB), which is publicly available upon request, and (2) newly computed basin-wide circulations for the four climatological seasons. We are ready to assess the level of agreement between our results and the circulation patterns obtained with the dynamical (geostrophic) method (Buljan and Zore-Armanda, 1976; Artegiani et al., 1997). In the process, we will also compare the circulations obtained when other existing dada bases (MED2, ATOS and MODAS) are used in our model. This is in order to separate the effect of using an improved data base from the impact of using more comprehensive dynamics than the geostrophic method.

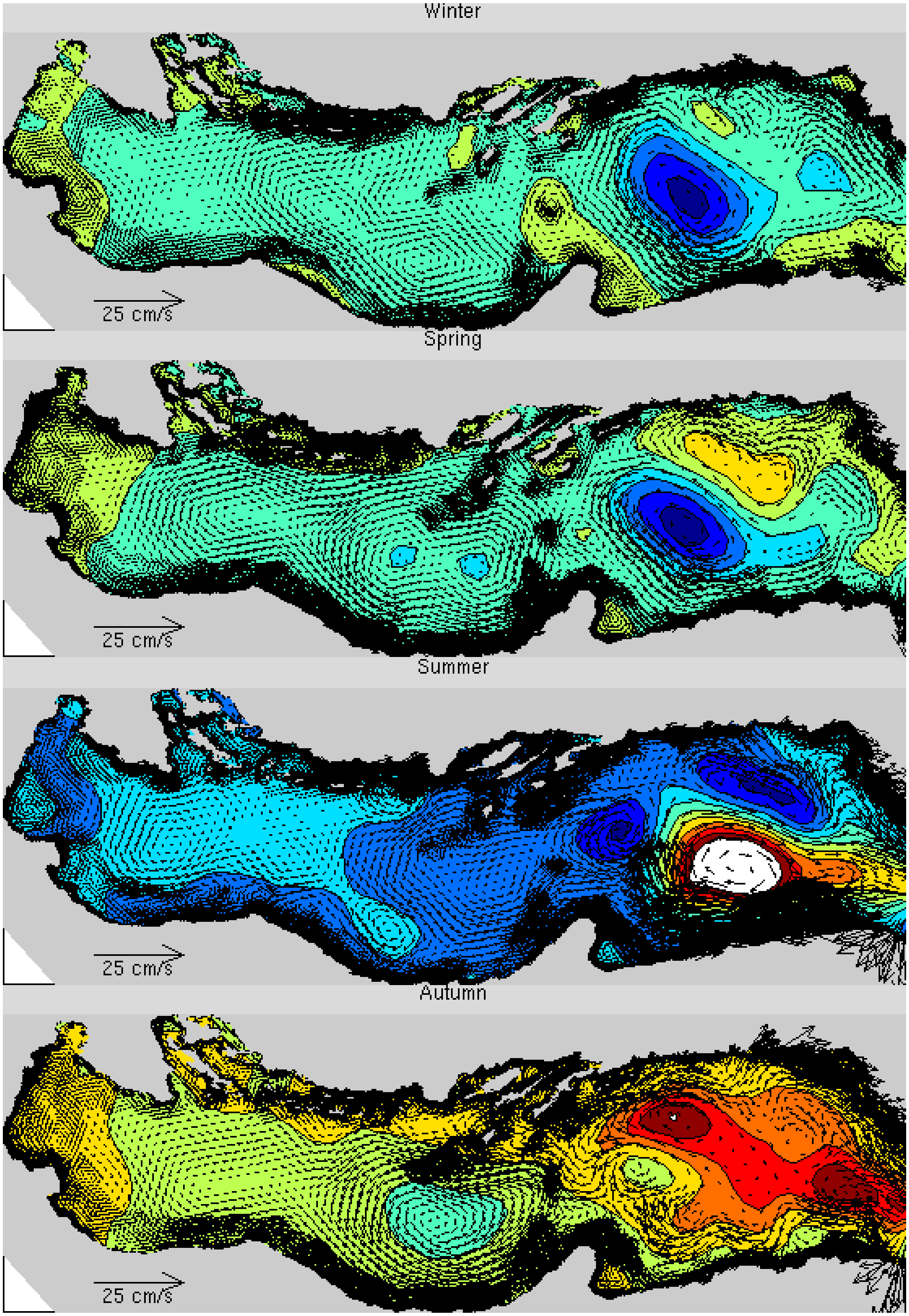

Figure 1. Seasonal circulation for the Adriatic Sea: Vertically integrated velocity vectors and transport streamfunction (0.25Sv contour interval) as calculated using the prognostic Dartmouth Circulation Model with forcing from regional tides, climatological winds, and the DADB hydrography.

We are also ready to compare our newly computed circulation patterns with the Eulerian circulation charts compiled from drifter data (Poulain, 1999b). Here, the comparison will address the effect of sparse observational sampling.

While a preliminary comparison shows qualitative agreement between circulation patterns simulated by the model and those constructed from the drifter statistics of Poulain (1999b), the agreement is far less satisfactory when numerical trajectories are compared directly to the individual observed tracks of Poulain (1999a). As a rule, the computed trajectories, even with inclusion of surface wind-driven currents, are shorter than their observed counterparts, indicating that modeled currents are weaker than actual currents. Work remains to be done, therefore, to identify the source of discrepancies. Perhaps, despite our best efforts to assemble the greatest possible number of data, the temperature and salinity distribution may still lack certain regional features, thus remaining excessively smooth and leading to geostrophic currents that are somewhat weak.

Although the comparison of the summer-1995 trajectories is still preliminary, the exercise has already showed that the wind can significantly redirect the currents in coastal and shallow regions.

IMPACT/APPLICATIONS

Fruitful collaborations have been established with research teams in Italy, Slovenia and Croatia. Our participation at the international workshop in Trieste and our book writing have further strengthened those relations. The ONR-supported Dartmouth initiative is now considered by the research community to be a substantial contributing effort to the study of the Adriatic Sea.

TRANSITIONS

Plans are to implement the Dartmouth Adriatic Sea Circulation Model at the Osservatorio Geofisico Sperimentale (Trieste, Italy) under the guidance of Dr. M. Gacic. There, the model will be used by both Italians and Slovenes for various basinwide and regional studies. We shall be providing technical assistance during this transition.

RELATED PROJECTS

1. Dr. P.-M. Poulain (Naval Postgraduate School) has conducted drifter experiments under ONR sponsorship. Our model is being used to compare actual and numerical drifter trajectories and to help improve drifter-launch strategies.

2. There are other, currently running models of the entire Adriatic Sea (at the Naval Oceanographic Office, at Mississippi State University - Stennis, in Bologna, and in Athens). We have developed and maintain contacts with the respective teams.

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PATENTS

None.